SUMMARY

A. BACKGROUND

The Space Systems Technology Working Group (SSTWG) study was formed as a result of two major concerns. The first was an industry concern about the export restrictions on militarily critical technologies, with the resulting negative effect on global space commercial business opportunities. The second was a recognition within the Department of Defense (DoD) and industry that the primary planning documents used to prioritize spending and to restrict foreign trade treated space technology in a cursory fashion rather than as a focused priority technology area. This study complements recent Joint Directors of Laboratory technology studies, directed towards fostering attention on critical military and military space technologies.

Examples of this casual treatment of space technology include the Militarily Critical Technology List (MCTL) space technology coverage, which gives fractional and varying levels of technical detail to space technology items scattered throughout the 15 established technology sections, and the DoD Key Technology Plan, in which space-unique technologies are scattered throughout the 11 recognized categories but space technology is **not** recognized as a distinct entity or category. This format makes it difficult to locate specific space technology items and to identify the unique performance parameters that determine if they are truly **critical space technologies that should be given priority support.** As a result, numerous space-related technologies are not addressed in the key DoD plans.

The United States has recognized the importance of space and space technology to its national and economic security since the beginning of the space era. Consequently, we have played a dominant world role in developing and using space technology. The importance of our **military and commercial space assets and their capabilities**, in peacetime and in combat, was demonstrated vividly during the buildup and conduct of the Gulf War. With the decline in available defense resources, the United States has an added impetus to identify **critical military space technologies**. Fully supporting all aspects of national planning **for the development of these technologies will**

contribute significantly to our continued military and commercial leadership in space.

U.S. space leadership in the 1960s, 1970s, and 1980s enhanced our economic strength and strengthened our technological and military capabilities. Recent global changes, including the fall of the Soviet Union and the emergence of new economic centers and alliances, place greater pressure on U.S. space leadership. More countries are competing for space leadership, and they are acquiring the needed technologies. If the United States does not aggressively pursue the goal of remaining the dominant space power, **other countries will seize the opportunity**. France is becoming the leader in low-cost, highly reliable commercial launchers, and Russia and China are working diligently to establish a commercial space industry. An awareness of these challenges within the Congress and recognition by other national leaders is crucial to build the foundation for the resource support necessary for continued U.S. leadership in space.

If the United States is to maintain its military space leadership role, the DoD must ensure that military space science and technology requirements are adequately **identified** and specifically defined and **documented so that critical space development programs** receive the required resource support.

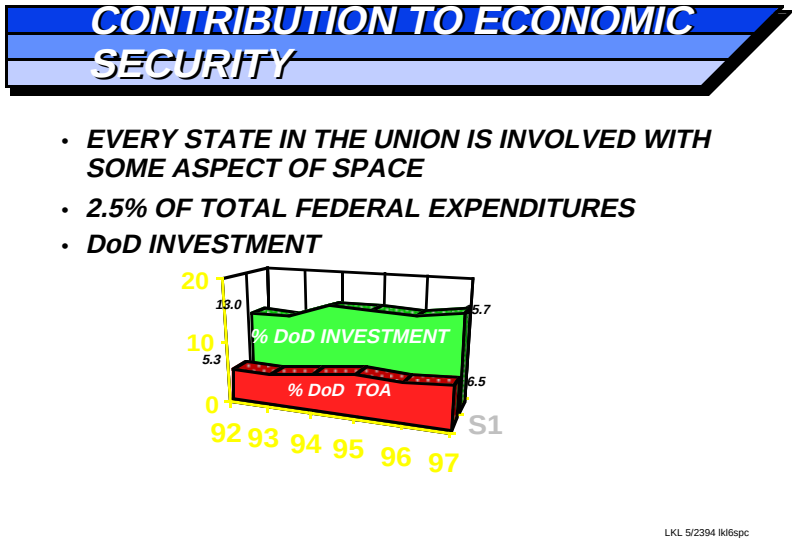
B. ECONOMIC IMPACT

Although the **military threat** to national survival—a characteristic of the bipolar Cold War years—is **greatly reduced**, the military **threat of regional conflict is, and will remain, high**. A more important and immediate menace to the United States **is the economic threat posed to the present U.S. aerospace industry.** The **U.S. share** of the global aerospace market **has dwindled significantly** in recent years. This market shrinkage has had a direct impact on the U.S. space industry as a whole, a fact emphasized in the recently completed *Space Industry Study* chaired by the Vice President of the United States.

In addition, the **European and Pacific Rim** countries are mounting **state-sponsored efforts** to become **leaders** in the **global aerospace market, particularly where there appears to be a commercial payoff (i.e., space communications and launch services).** Substantial investments have been made to support research, development, test, and evaluation (RDT&E) facilities and to educate scientists and engineers. **Business leverage alliances** and **partnerships** are growing between governments, industry, and their educational institutions. **If this trend continues, the**

United States could be relegated to second place (or worse) in many categories of the world aerospace market early in the 21st century.

The space contribution to our national economy is considerable. Every state in the union has research, development, or manufacturing activities related to current and projected space efforts. Space expenditures currently amount to more than 2.5 percent of the Federal Budget (about $35 billion) and represent 15 percent of the DoD investment account through 1997. The $5 billion commercial space export business in 1991 was the equivalent of exporting about 500,000 automobiles. This export business could increase significantly if the United States maintains its competitive edge in the development of new cost reducing technologies with advanced systems capabilities.



The question is as follows: How can the United States best exploit its space technologies and maximize the contribution of these technologies to military and economic security? The United States' long-term investment in the military capability necessary to defend the itself must be protected. Pressures from U.S. industry for expansion into commercial space markets around the world will continue, and limiting the access of space technologies to these foreign markets must be weighed carefully. Today, U.S. space industry access to the global market is often being restrained through limitations on the **foreign sale of dual-use technologies.** For the space-critical technologies at risk, the challenge for the U.S. government is to **achieve a reasonable and prudent balance between national security requirements, military interests,** and **economic interests.** To be successful, government and industry must communicate and coordinate.

One approach to managing dual-use technologies is to emphasize **selling products or allowing the use of the technology products rather than selling**

the development and production technologies themselves. A good example of this approach is land satellite (LANDSAT) imaging. Images, not the optical systems that produce these images, are sold commercially. Another approach is to develop more cooperative research agreements between government and industry to pursue reduced-cost launcher and payload technologies and more international cooperative agreements with other friendly countries.

C. DISCUSSION

The ability to manage space technologies and capabilities is critical to overall U.S. space leadership, especially in the management of dual-use space technologies. Greater use, both commercially and militarily, will lower the unit cost to all users. For the militarily critical space technologies, their security value versus commercial access to them and the resultant effect on our global competitive position will require continual evaluation. A continuing dialog about U.S. long-term objectives is required to provide the basis for identifying and restricting those few militarily critical space technologies that should not be exported because of national security reasons. With the emphasis on broadening the global commercial opportunities for all technologies, including space, DoD will need sound and very specific rationales for the technologies judged to be militarily critical.

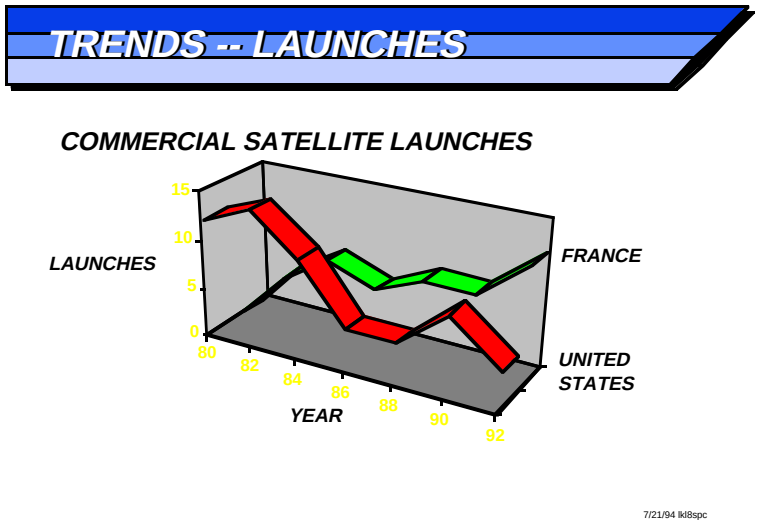
As the United States transitions from policies that governed past export controls, it must recognize the need for changes and make the needed adjustments. Today, **some noncritical technologies,** such as **all** "space-qualified" cryocoolers, **are controlled. Under the new export control regime, noncritical technologies must be reevaluated to determine whether controls are necessary**. The past definitions were too general and covered categories of technologies rather than specific technology elements, items, or systems. However, we have identified **three technologies that are not controlled but are *critical* and should be controlled.** When such technologies are identified, the United States must effect prompt changes in export controls. In the first case, the penalty for not acting is the **loss of commercial sales** and their attending economic impacts. In the second case, the potential **loss of a militarily critical technology** that adversely affects U.S. national security is a real possibility.

The ability to properly define critical technologies, to adequately assess their priority in relation to U.S. security requirements, and to effectively communicate this information to DoD and Congressional leadership provides the best assurance that funding for these critical space technologies will be forthcoming. **Without adequate visibility**

and understanding of space technologies' military and economic contributions, the needed support to bring these technologies to full maturity will erode.

D. TRENDS

A relatively flat trend in U. S. defense space budgets is forecast over the next few years. In total, the U.S. **commercial space market is expected to continue to grow, albeit slowly.** The greatest growth areas are expected to be communications and ground surveillance systems. Forty new communication satellites are scheduled for launch in the next 5 years. These launches are projected to result in a nominal 4 percent growth per year in new space-based C/Ku-band transponders.



On the negative side, **U.S. commercial launch capability is not as cost effective as that of our foreign competition. As a result, we are now launching fewer commercial satellites than the French.** In the 1991–1992 period, France launched 12 satellites, and the United States launched 4 satellites. **This situation, if unchanged, will have serious long-term implications for the U.S. space program.**

The public space euphoria of the early 1980s, with talk of long duration space missions and future colonization, has subsided. Recent congressional actions suggest that space, as a priority, has taken a back seat to the demands for budget balancing and increased funding for social concerns. **Highlighting and emphasizing to the public and Congress the value and importance of today's space technologies should have a positive direct effect and provide the best opportunity to maintain U.S. space dominance.**

E. TECHNOLOGY INVESTMENT

Technology investment has the potential payoff of maintaining U.S. technological performance leadership and a leveraged position in the world economic arena. Countries and companies that have large research and development (R&D) investments appear to do well. With new technologies, the challenge is obtaining the needed investment up-front to realize the desired long-term benefits.

The French Ariane is an example of a technology investment strategy that has paid dividends. By investing in launch operations with modernized and automated checkout and launch, Ariane can launch a *comparable* Atlas Centaur or heavy-lift Titan IV with a 100-person ground crew in about 10 days. In comparison, the United States needs 300 people and 55 days to launch an Atlas Centaur and 1,000 people and 90 days to launch a heavy-lift Titan IV. Through this quick, low-cost launch service, the French are capturing most of the world's commercial satellite launch business.

The **United States has the enabling technologies to lead in low-cost launch systems.** However, we lack **national priority, investment strategy, and resource support to systematically develop these technologies for the next-generation propulsion systems and launch vehicles.**

Given this, the crucial questions are as follows: How can the United States best exploit space technologies and maximize the contributions of these technologies toward our military and economic security goals and objectives? How can the United States provide cost-effective technological advances to overcome other countries' leads in specific areas of space capabilities?

During this study, the technology subgroups made judgments about the adequacy of current critical technology support. These judgments, though outside the charter and objective of the SSTWG, were included because of their potential utility for the offices and agencies responsible for developing these technologies.

F. RESULTS

This study identified and described the key quantitative parameters of militarily critical space technologies and categorized the dual-use potential and military significance of these technologies to provide a basis for policy and support priority decisions.

Of primary concern to DoD is the overall category of technologies that are "militarily critical." These technologies are defined as those that are essential to

accomplishing a military mission or objective—especially in overcoming a military mission area deficiency—or are new enabling technologies that have potential for significant increase in a military capability. They represent the key to maintaining military space capability leadership.

"Space-unique" technologies are those that support only the space mission. This important category of military critical technologies is identified in this study but, at this time, is not specifically recognized in key DoD documents. These technologies are not automatically being nurtured by other nonspace mission thrusts. Visibility to senior DoD and Congressional officials is key to future development of these technologies.

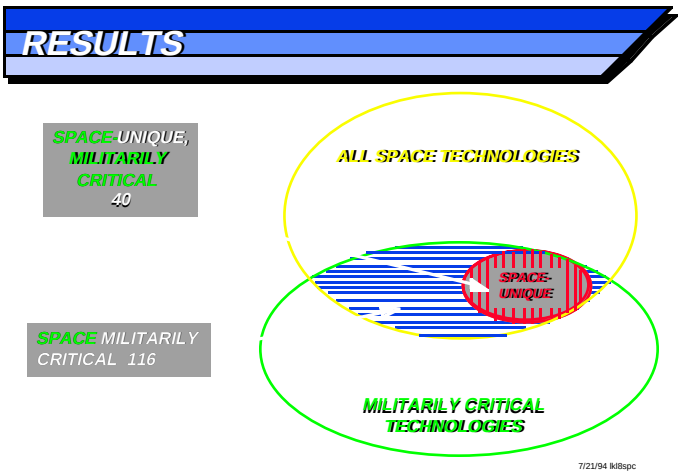
Also identified are "dual-use" militarily critical technologies that have the potential for military and commercial applications, with payoff for both. By being more precise and improving the definitization of parameters that describe these dual-use technologies, the United States can release formerly controlled technology for commercial export to strengthen its space industry and, at the same time, protect those technologies that support security requirements.

Having categorized these technologies, part of the study charter was to examine the implications of export control and "dual-use." Some commercial dual-use technologies do not contribute to militarily significant technology since their operating parameters or functions are significantly different. A case in point is the electronic components of some military communication satellites that must operate in a more hazardous radiation environment than the equivalent commercial satellites.

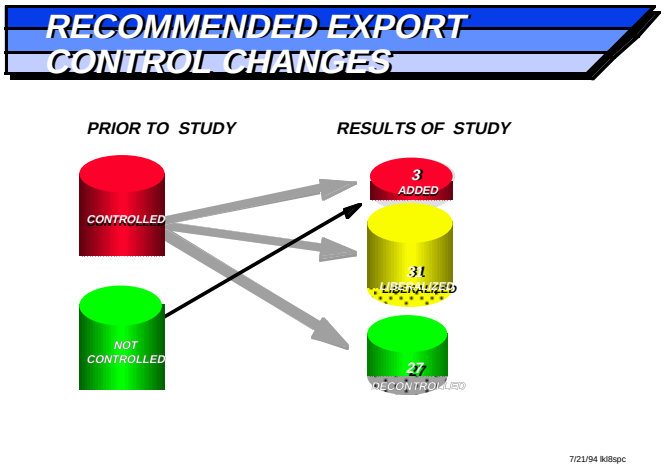
Since visibility and support are fundamental to furthering the R&D of these space-unique militarily critical technologies, the SSTWG investigated the prospect of entering into partnerships through Cooperative Research and Development Agreements (CRDAs) with industry and Memorandums of Understanding (MOUs) with specific allied nations to more effectively develop the technologies. Section III lists specific recommendations for each technology.

G. CONCLUSIONS

The SSTWG study concluded:



1. All Services need an **integrated space mission area "road map"** to provide a firm basis for space technology planning and prioritization. Space technologies are not adequately recognized as an individual category in the MCTL and in key DoD planning and funding documents.



2. Modifications to the development **process** techniques of systems engineering and integration (SE&I) as applied to space systems (defining, developing, manufacturing, integrating, testing, launching, and on-orbit operations) have significant potential for greater efficiencies, cost saving, assured access to space, and continued U.S. space leadership.

3. **Forty technologies** of the **116 militarily critical space technologies**, have been identified and categorized as **critical space unique** and should be recognized as such in the appropriate DoD documentation.

   Of these, 37 are dual-use. These dual-use technologies require more precise and explicit parameters to ensure that only critical items are controlled and those outside the explicit parameters are made available to the open commercial market.

   Thirty-six technology areas that have high payoff potential and are candidates for additional investment have been identified.

Sixty-one technologies were recommended for a change in their export control status: 27 of these were recommended for decontrol; 31 were recommended for less stringent control; and 3 not currently controlled were recommended for control.

Sixty-three technologies have been identified as candidates for partnerships through CRDAs and specific international agreements (MOUs).

4. **Payload modules, buses, and interfaces must be standardized** to improve technology insertion and provide improved interoperability and savings within the military and commercial space community.

5. **Selling the products of space technology or on-orbit capabilities** rather than selling the specific technology has the significant potential of **protecting the U.S. job and production base** and the associated development and production technologies. This practice has already begun with the Global Positioning System (GPS) services and high-resolution space imagery products ($400 million in 1993 and a potential $2 billion in 2000).

These space technology areas are treated in more detail in the "Technical Report," IDA Document D-1521. Summary tables of each technology area are included in Section III of this document.

H. RECOMMENDATIONS

Based on these conclusions, the SSTWG makes **the following recommendations**:

1. **Space systems technologies** should be included as a separate, unique section in all future versions of the MCTL.

2. **Key DoD planning and resource documents** (such as the Defense Science and Technology Strategy and the DoD Key Technology Plan) **should treat space technology as a separate, unique area.**

   Specifically, DoD should create an integrated space mission area road map to provide a firm basis for space technology prioritization and development.

3. An existing advisory board, such as the Defense Science Board (DSB), should **identify SE&I practices** that have been successful in other key industries and that can be applied to space programs.

4. The United States should **include unique critical space systems technologies in the new international export control regime and incorporate recommended changes**.

5. **Where beneficial, the United States should pursue both domestic and international partnerships through CRDAs and MOUs for identified space system technologies to bring these technologies into production sooner and at lower unit cost.**

6. **DoD should take the initiative** for the government and industry in **defining interface standards and should encourage standardization for launch vehicle payloads, payload interfaces, and modular space components**.

7. The United States should **emphasize selling complete space systems or using the products** of space technology rather than selling the development and production technologies themselves. This practice would improve the U.S. job outlook and protect the critical technologies involved.

Implementing these recommendations will provide impetus and rationale for ensuring that unique space-critical technologies are adequately recognized and that the necessary investment is made *now* to ensure that the United States continues its leadership in military space capabilities into the 21st century.

I. REVIEW PANEL

The following page lists the members of the SSTWG Review Panel.